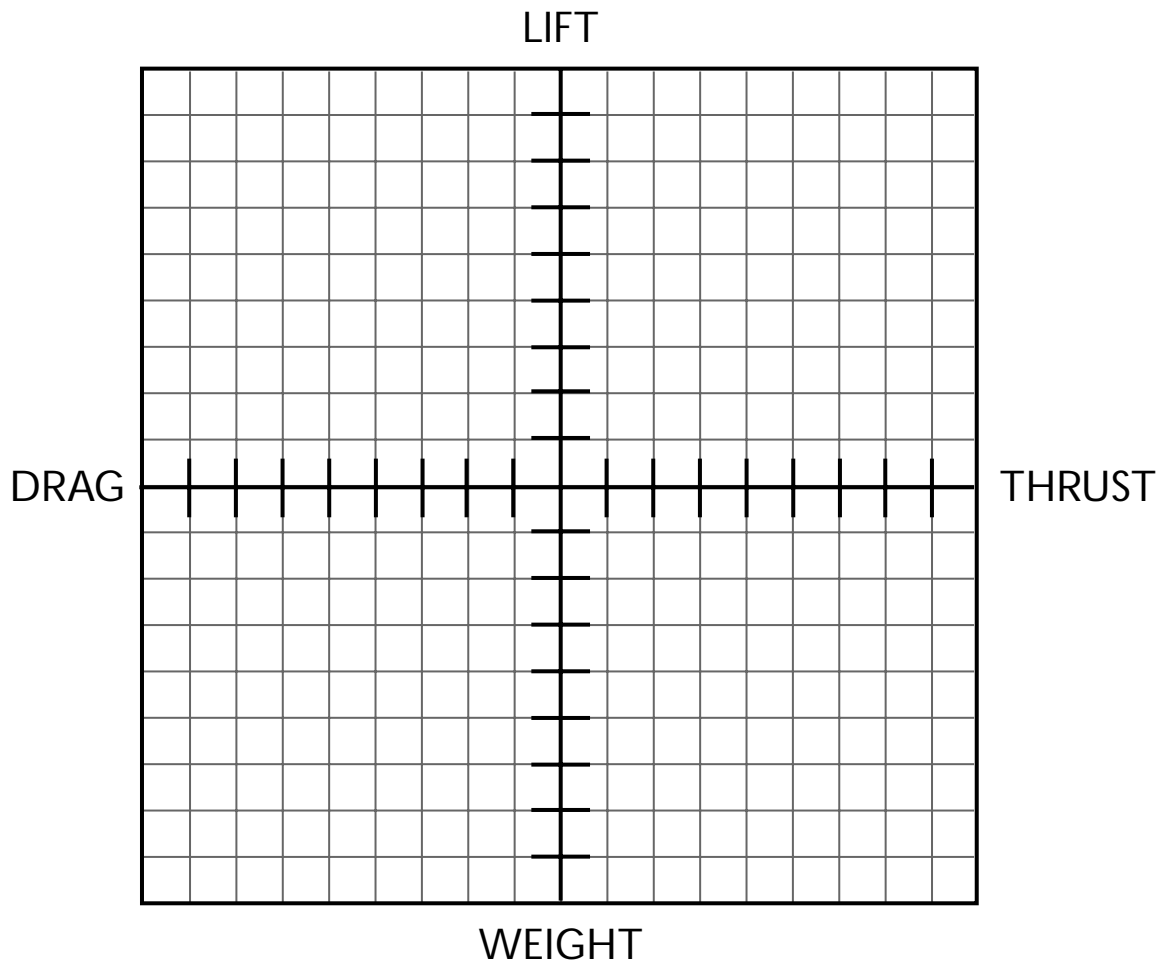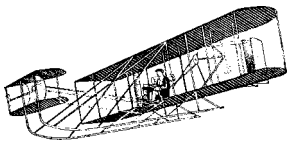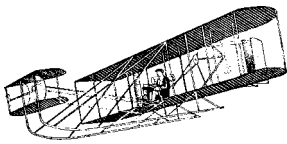# Graphing the Four Forces

Background: The concept of force can be effectively represented on a graph using the Cartesian coordinate system. By representing four of the aeronautical forces (lift, drag, thrust, weight) on a graph, students can visualize both parts of the definition of force: magnitude and direction.

In the lesson, Computing the Net Force, students learned how to calculate the magnitude and direction of the net force, given two parallel forces. In this lesson, students will use information about four forces to make a decision about whether or not an airplane is (theoretically!) able to fly.

This lesson concentrates on the actual representation of the forces on a graph. If, after combining the four forces, the net force is plotted in the upper right quadrant of the graph, then we will draw the conclusion that the airplane is able to fly.

Directions: Have students examine the graph on the following page. Point out that lift is "<u>up</u> toward the top of the paper", weight is "<u>down</u> toward the bottom of the paper", thrust is "<u>forward</u> toward the right of the paper" and drag is "<u>back</u> toward the left of the paper".

LIFT

DRAG

THRUST

WEIGHT

Using the magnitudes below, follow the steps and plot your points on the graph on the previous page.

| Weight	3 units
Lift	7 units
Drag	2 units
Thrust	5 units

The forces can be plotted in any order. For example:

Step 1: Start at the origin and count down three squares (for Weight). Plot a small dot.

Step 2: From that small dot (do not start again from the origin!) count up seven squares (for Lift). Plot another small dot.

Step 3: From that small dot (do not start again from the origin!) count to the left two squares (for Drag). Plot another dot.

Step 4: From that small dot (do not start again from the origin!) count to the right 5 squares (for Thrust). Plot a large dot. This is the representation of the net force.
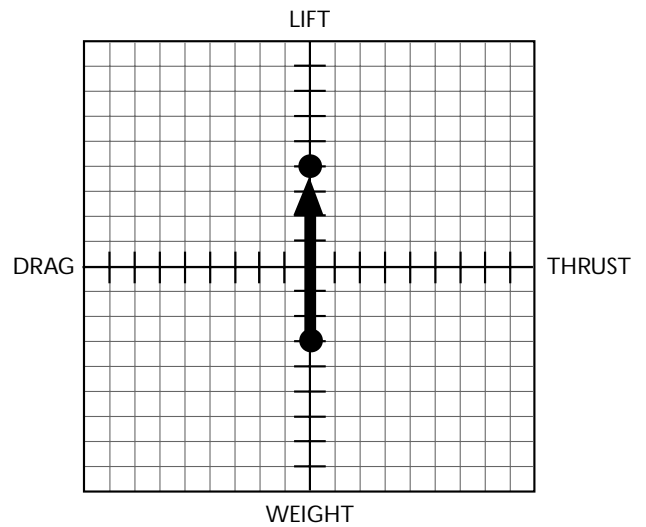
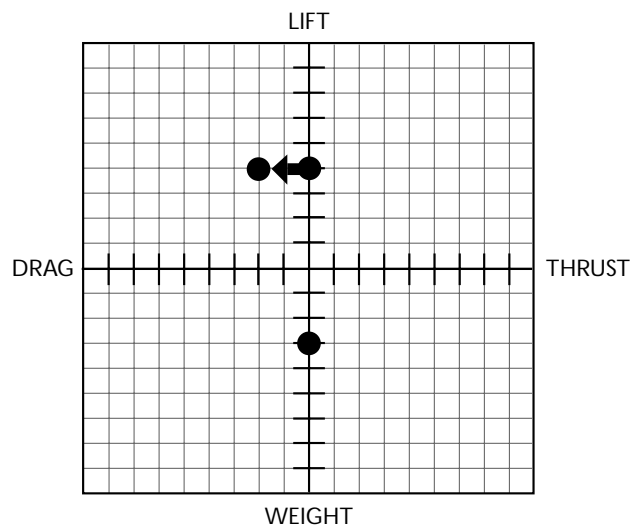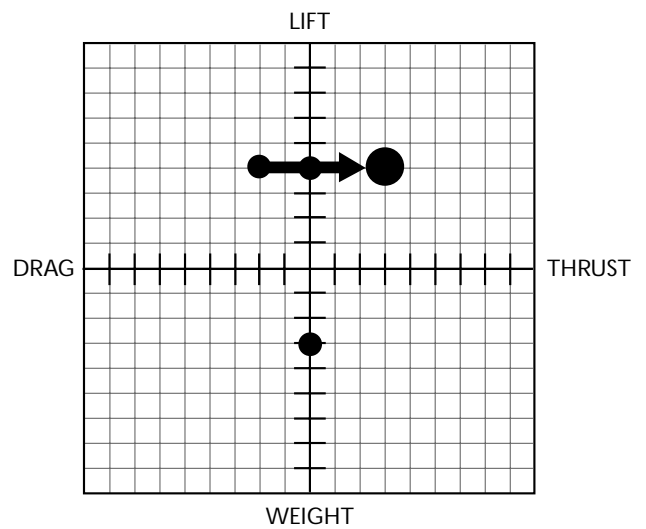See the graphs on the following page for guidance, then continue.
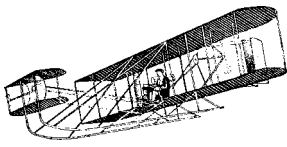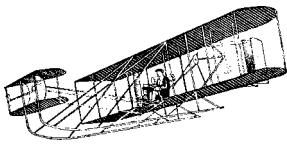
Step 1: Down 3
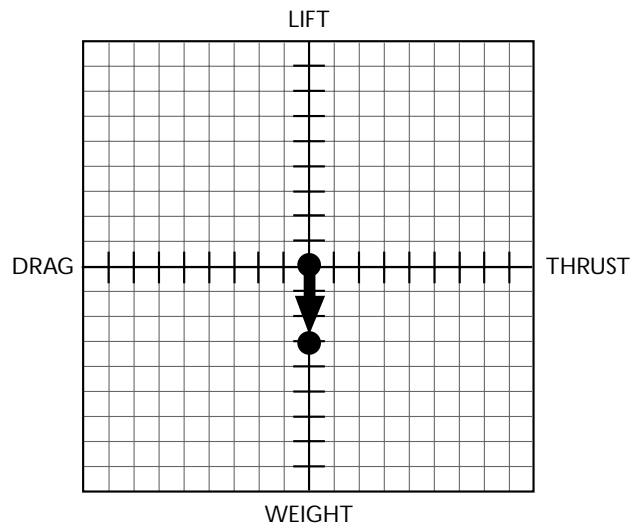
Step 2: Up 7

## Step 3: Left 2

Step 4: Right 5

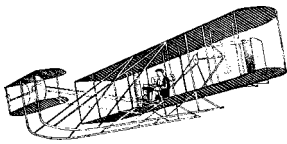**Step 5:** Determine whether or not the airplane is flyable.

If the net force is plotted in the upper right quadrant, the airplane is flyable.

If the net force is plotted in the upper left quadrant, the airplane is not flyable - it has too much drag.

If the net force is plotted in the lower left quadrant, the airplane is not flyable - it has too much drag and weight.

If the net force is plotted in the lower right quadrant, the airplane is not flyable - it has too much weight.
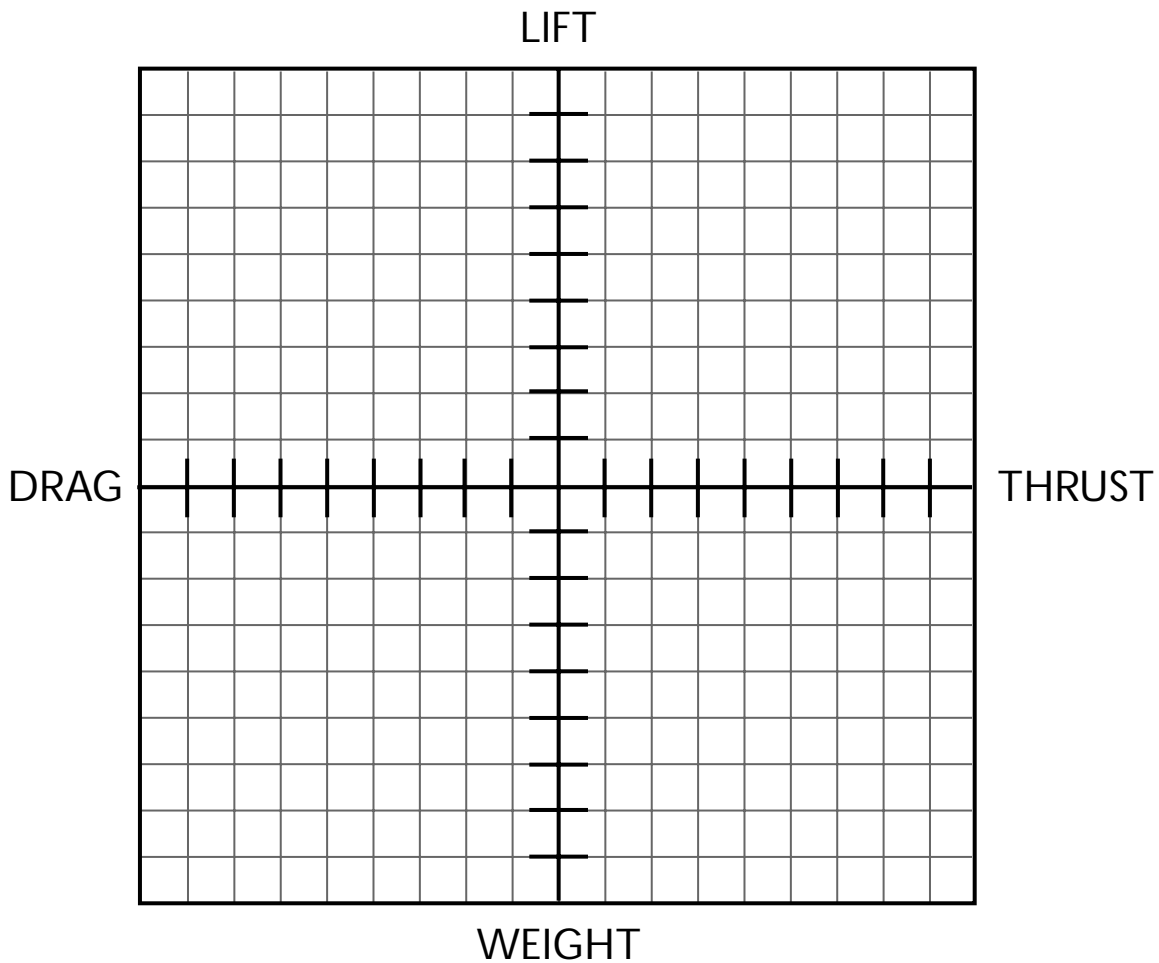
LIFT

too much drag	airplane is flyable

DRAG — THRUST

too much weight and drag	too much weight
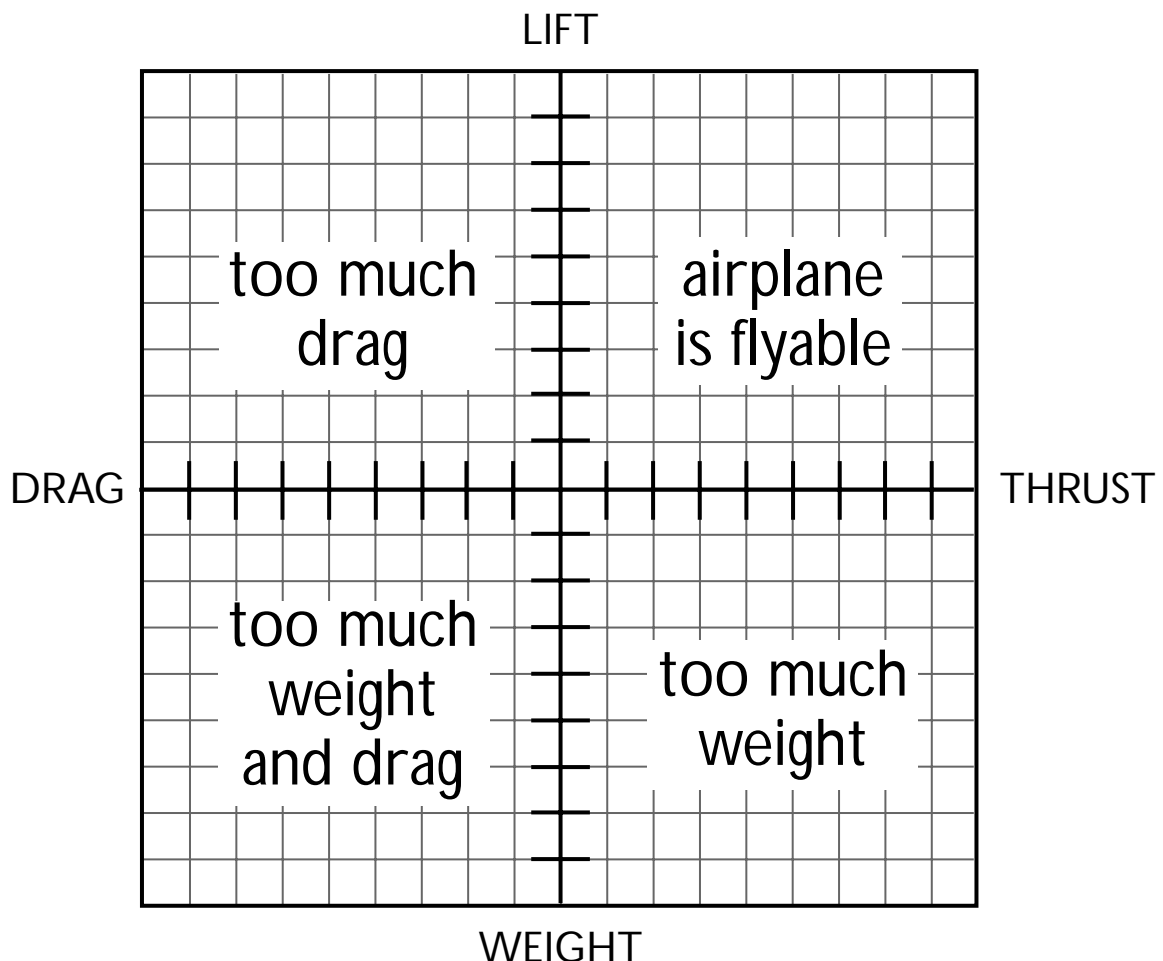
WEIGHT

Exercise 1

Directions: Use the steps from the previous example to plot the following magnitudes. After you plot the net force, make a decision about whether or not the airplane is flyable.

Weight	4 units
Lift	10 units
Drag	2 units
Thrust	10 units

LIFT

DRAG

THRUST

WEIGHT

Question 1: This plane is / is not flyable.

Question 2: If it is not, tell what force or forces are too great for the airplane to fly.
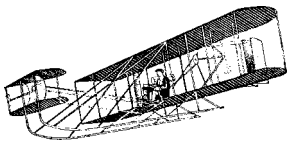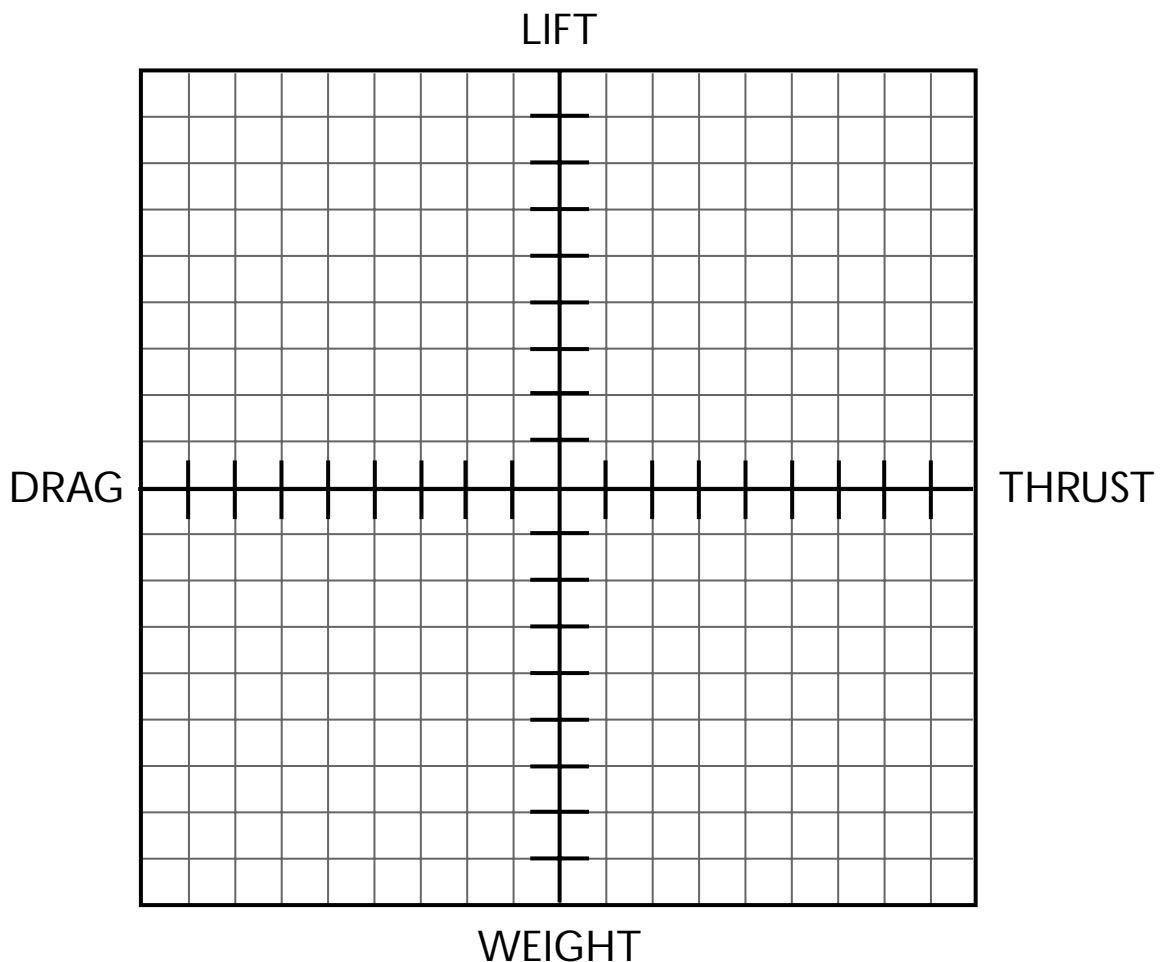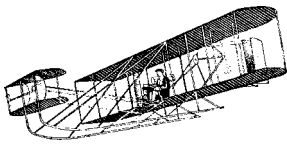
Exercise 2

Directions: Use the steps from the previous example to plot the following magnitudes. After you plot the net force, make a decision about whether or not the airplane is flyable.

Weight	8 units
Lift	4 units
Drag	6 units
Thrust	4 units

LIFT

DRAG   THRUST

WEIGHT

Question 1:   This plane is / is not flyable.

Question 2:   If it is not, tell what force or forces are too great for the airplane to fly.

Graphing the Four Forces

Exercise 1 - Key

Starting at the origin:
the end of the weight arrow will be at (0,-4)
the end of the lift arrow will be at (0,6)
the end of the drag arrow will be at (-2,6)
the end of the thrust arrow will be at (8,6)

since (8,6) is in the upper right quadrant, the airplane is flyable

Note: the arrows may be drawn in any order, you will always end up at the same place!

Exercise 2 - Key

Starting at the origin:
the end of the weight arrow will be at (0,-8)
the end of the lift arrow will be at (0,-4)
the end of the drag arrow will be at (-6,-4)
the end of the thrust arrow will be at (-2,-4)

since (-2,-4) is in the lower left quadrant, the airplane is not flyable

both weight and drag are too great